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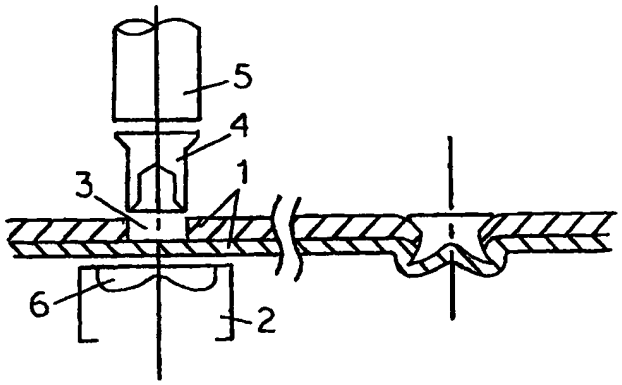

(57) Abstract

A method of joining two or more members (1, 1) at least one of which is a sheet material by means of self-pierce rivetting is described. The combined thickness of the members (1, 1) is reduced at a region (3) within which a self-pierce rivet (4) is to be introduced without creating a hole which extends through all the members (1, 1).

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IMPROVED MEANS OF FASTENING SHEETS BY RIVETING

TECHNICAL FIELD

This invention relates to a novel method of fastening sheet material by the use of a self-piercing rivet.

The term "self-piercing" is used in relation to rivets to define tubular, or part-tubular rivets which can be used to fasten together two or more sheets of material without the requirement for a preformed hole or holes through the sheets. There are many applications in industry where self-piercing rivets can be advantageously employed by virtue of their economy, and the high security fastening which they provide.

Sheet material can be produced by many methods, such as rolling, extruding or casting. When extruded or cast it can be produced integrally with an extruded or cast profile. It can be formed from a variety of materials, such as metals, plastics, wood or glass.

Prior to the development of self-pierce riveting the conventional method of riveting sheet material involved pre-piercing or pre-drilling holes in each sheet, aligning the holes and then inserting a rivet to fasten the sheets together. The time consuming and expensive part of this process was usually the aligning of the holes, particularly when each sheet had a number of holes each of which required alignment. Because of the alignment problem pre-piercing or pre-drilling often was not feasible and the fastening holes in at least one sheet had to be put in after the sheets had been brought together.

BACKGROUND ART

Conventional self-pierce riveting overcomes this problem by eliminating the need for pre-pierced or pre-drilled holes. It secures the sheet material by driving a rivet, using a rivet applicator, into the sheets of material at right

angles to the plane of the sheets. As the rivet is forced into the two sheets it acts initially as a piercing punch so that a slug of material defined by the piercing of the material by the rivet lies within the hollow of the rivet. Thereafter the slug is driven forwardly with the rivet and the combined slug and rivet act as a drawing punch on the material in their path. The riveting apparatus further includes a female die having therein a circular recess with a centrally disposed upstanding anvil, into which material displaced by the forward movement of the combined slug and rivet is drawn. As the displaced material reaches the anvil of the female die it is trapped between the advancing rivet and the anvil. Further forward movement of the rivet and slug causes the tubular portion of the rivet to roll radially outwardly. The tubular portion of the rivet is thus spread radially outwardly and the material displaced is shaped by the recess of the die.

A major drawback of conventional self-pierce riveting is that in order to have the strength to pierce the sheet material without collapse, the rivet size has to be far greater than that required to provide an effective fastening. The normal mode of failure when a riveted joint is taken to destruction is for the sheet material to stretch until it is pulled clear of the rivet. The rivet itself does not normally fail under functional load because the strength it requires to pierce its way into position within the sheet is greater than the strength required to resist the forces transferred to it by the sheet as the sheet reaches its yield point.

A further drawback of conventional self-pierce riveting is that it causes cracking of the displaced material of the lower sheet when the ductility of the lower sheet is low as with, say, cast or extruded aluminium. If a large rivet is required to pierce the materials concerned the volume displaced is also large and the stretching involved may take the displaced material beyond its yield point.

Yet a further drawback of conventional self-pierce riveting is that it is limited in its ability to fasten thin material to the underside of thick material because a rivet which is strong enough to pierce the thick material is too strong to roll within a thin lower sheet.

DESCRIPTION OF THE INVENTION

It is the object of the present invention to provide a design of self-piercing rivet and a method of self-pierce riveting wherein these and other disadvantages of conventional self-piercing are obviated or minimised.

We have found that we can in many applications replace a conventionally sized self-piercing rivet with a much smaller self-piercing rivet and still achieve equal security of fastening if we :

1) reduce the thickness of the sheet material to be pierced by the rivet by removing sheet material at the riveting point. The material may be removed from the upper or lower sheet by any of the conventional metal removing processes, i.e. by drilling and piercing. The removal may generate a hole, partly or fully, through the sheet; and

2) design the rivet to self-pierce the remaining material; to generate the necessary interlock between the sheets; and to have sufficient shank expansion to fill the cavity generated by the removal of the sheet material.

The invention may be considered to provide, in one aspect, a method of joining two or more members at least one of which is a sheet material by means of self-pierce rivetting in which the combined thickness of the members is reduced at a region to be rivetted without creating a hole which extends through all of the members, self-piercing rivet is introduced at that region.

The rivet required for our novel method of fastening has unique features:

a) it needs a shank of sufficient length to pass through any hole in the upper sheet and still be adequate to generate a roll within the lower sheet;

b) it needs a shank of sufficient strength to support the rolling action in the lower sheet until the sheet is adequately secured without allowing shank expansion to cause frictional grip on the walls of the hole in the upper sheet, whilst allowing shank expansion after adequate rolling has taken place in order to fill the hole in the upper sheet completely.

c) it allows the shank/head interface to contain a sufficient fillet of material to generate interlock between the sheets.

By means of our invention :

1) we reduce the material displaced from the sheets into the die during the application of the rivet, and hence widen the range of materials which can be fastened in this way without the displaced material cracking, and also reduce the thinning of any protective coatings on the lower sheet;

2) we increase the sheet thicknesses which can be fastened by self-pierce riveting. As the sheet thicknesses increase, the size of rivet and the size of the rivet applicator required to fasten them by conventional self-pierce riveting increase rapidly, and this imposes an upper limit for practical purposes to the sheet thicknesses which can be fastened in this way;

3) we reduce the weight added to assemblies by the fastener. This can be very significant when large numbers of steel rivets are used to fasten light-weight materials, such as aluminium in light-weight vehicles;

4) we reduce the fastening pressures required and hence facilitate the use of smaller more mobile rivet applicators;

5) we reduce the number of rivet geometries required to cover a range of applications because by varying the amount of material removed by drilling or piercing, a single rivet geometry can be used to fasten a wide range of sheet thickness combinations;

6) we eliminate the need for the displaced material to protrude from the lower sheet. Often it is important that there is no protrusion and, by locally removing metal from the lower sheet into which the setting die can fit, we can ensure that the displaced material does not protrude beyond sheet level;

7) we make possible the pre-positioning of rivets. The point here is that in self-piercing it is vital that the rivet is presented completely square to the workpiece, and this can normally only be achieved by a well engineered guidance system. In our invention, if the upper sheet is drilled or punched, a rivet inserted manually or by machine can be held precisely in alignment, without the need for a guidance system, prior to fastening by a rivet applicator;

8) we can maximise the sheet interlock by designing the rivet with a circumferential fillet of material at the junction of the shank and the head;

9) we can design the rivet so that solid shank material lies at the interface between the two sheets to increase the shear strength of the fastening;

10) we can eliminate the danger of premature roll. The point here is that for effective fastening it is necessary to ensure that the rivet enters the lower

sheet at the very early stages of rolling, otherwise there is a danger that it will roll at the interface without ever entering the lower sheet;

11) we permit the use of smaller rivets which are less expensive to produce;

12) we have the facility to fasten brittle materials to a substrate by generating a hole in the brittle material through which the shank of a rivet can pass prior to being set in the substrate, thereby effectively securing the brittle material between the substrate and the head of the rivet;

13) we can successfully fasten thin material to the underside of thick material when the disparity in thickness is such that conventional self-pierce riveting is unable to cope. The point here is that if the rivet needs to be strong enough to pierce completely through the thicker material it is often not possible for it to roll within a thin or soft lower sheet without breaking through. With our invention sufficient material can be removed locally from the upper sheet to allow the use of a rivet which can roll within a thin or soft lower sheet.

14) we can design a rivet according to our invention to act as a very effective alternative to a weld stud by passing a rivet through a hole in the upper sheet and setting it by the normal self-piercing action in the lower sheet. With this construction the upper sheet can provide side-ways support and this, combined with very effective anchoring achieved by the normal rolling action of the tube, provides a secure peg which can protrude any desired amount above the upper sheet.

Our novel method of fastening retains all the advantages of conventional self-piercing in terms of security of fastening, airtightness and watertightness, and is very versatile in terms of the materials which it can fasten. These include

metal, plastic or composites, rolled-sheet, cast, extruded or moulded. It is also versatile in terms of the volume of material removed from the sheet. For instance a drilled hole may pass partly through the upper sheet or totally through it, and in some instances even pass into the lower sheet, whilst in all cases leaving enough material to effect a secure fastening.

When riveting in accordance with our invention it is, of course, necessary to position the rivet applicator accurately relative to the hole in the upper or lower sheet. With a manually-held rivet applicator this can readily be achieved by touch as the nose or die of the rivet applicator engages the hole. In the case of a rivet applicator mounted on a robot or other special purpose machine, the hole position can readily be sensed by the use of laser beams which detect the presence of a hole and provide a signal which causes the controlling mechanism of the rivet applicator to position it correctly.

DESCRIPTION OF DRAWINGS

Our invention can readily be understood by reference to Figures 1 - 7 which show a number of typical combinations of sheet geometries which can be fastened according to our invention.

MODES OF CARRYING OUT THE INVENTION

Fig 1A shows two sheets of material 1 positioned above a setting die 2. The top sheet of material 1 has a through-hole 3 to receive the shank of rivet 4 which is forced by plunger 5 through hole 3 into the lower sheet of material 1. The material displaced from the lower sheet of material 1 is forced into cavity 6 of die 2. Fig 1B shows a sectional view of rivet 4 after being set within material 1.

For the sake of clarity die 2 and plunger 5 are omitted from Figs. 2A, 2B, 3A, 3B, 4A, 4B, 5A, 5B, 6A, 6B, 7A and 7B.

Fig 2A shows material 7 the lower sheet of which has a partial hole 8 into which the material displaced when rivet 4 is set within material 7 can be contained to give a flush finish 9 on the lower sheet, as shown in Fig 2B.

Fig 3A shows material 10 the upper sheet of which has a through-hole 11 to receive the shank of rivet 4, and the lower sheet of which has a partial hole 8. As in Fig 2B above, the displaced material can be at least partially contained within hole 8 as shown in Fig 3B.

Fig 4A shows material 12 the upper sheet of which has a partial hole 13 to receive head 14 of rivet 4 when rivet 3 is set within material 12, as shown in Fig 4B.

Fig 5A shows material 15 in which the upper sheet has a 2-diameter through-hole 16 to receive the head and shank of rivet 4 when rivet 4 is set within material 15, as shown in Fig 5B.

Fig 6A shows material 17 which consists of three sheets, the upper of which contains through-hole 18 into which the shank of rivet 4 can pass when being set within material 17, as shown in Fig 6B.

Fig 7A shows material 19 which consists of three sheets with through-hole 20 in the upper two sheets and partial hole 21 in the lower sheet. Fig 7B shows a sectional view of rivet 4 set within material 19.

CLAIMS

1. A method of joining two or more members (1,1) at least one of which is a sheet material (1) by means of self-pierce riveting characterised in that the combined thickness of the members is reduced at a region (3) within which a self-pierce rivet (4) is to be introduced without creating a hole which extends through all the members.

2. A method according to claim 1 wherein the thickness is reduced by creating a hole (8) extending from an exposed surface of the member (7) partially through the member which is most remote from the head of the set rivet (4).

3. A method according to claim 1 wherein the thickness is reduced by creating a hole (13) extending from an exposed surface of the member (12) partially through the member which is adjacent the head of the set rivet (4).

4. A method according to claim 3 wherein the hole is of such dimension as to snugly receive the head (14) of the rivet (4).

5. A method according to claim 1 wherein the thickness is reduced by creating a hole (3; 11; 16; 18; 20) extending completely through that member (1; 10; 15; 17; 19) which is adjacent the head of the set rivet (4), the hole extending from an exposed surface of the member and being of such dimension that the rivet head cannot pass through the hole.

6. A method according to claim 5 wherein the hole is of such dimension that a rivet shank can be slidingly received in the hole.

7. A method according to either one of claims 5 or 6 wherein the hole (20) extends into a member (19) adjacent that through which the hole extends completely.

8. A method according to any one of the preceding claims wherein the thickness is reduced by creating two opposed holes (8, 11; 20, 21) extending into the assembled members (10, 10; 19, 19) from opposite exposed surfaces.

9. An assembly comprising a plurality of members riveted together by a method according to any of the preceding claims.

FIG 1A

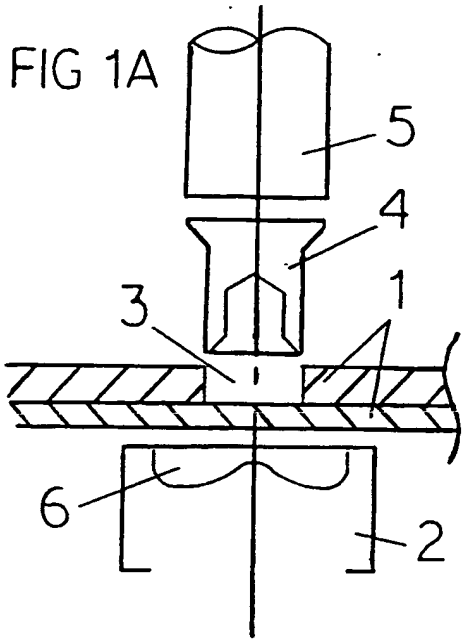

FIG 1B

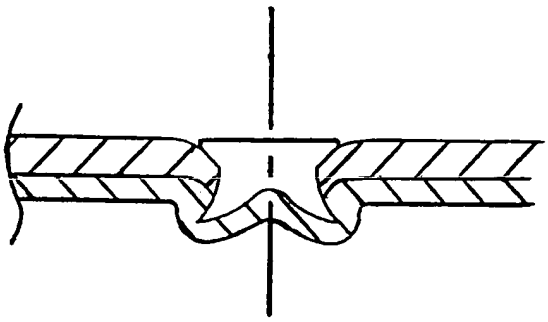

FIG 2A

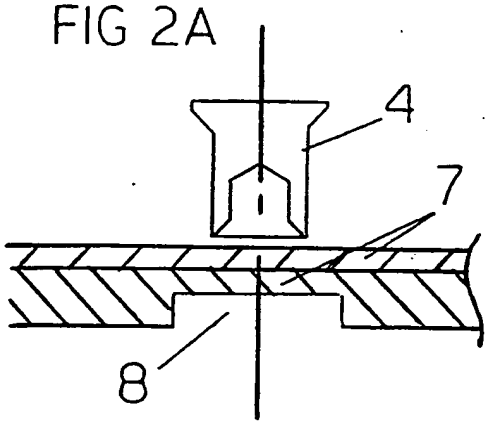

FIG 2B

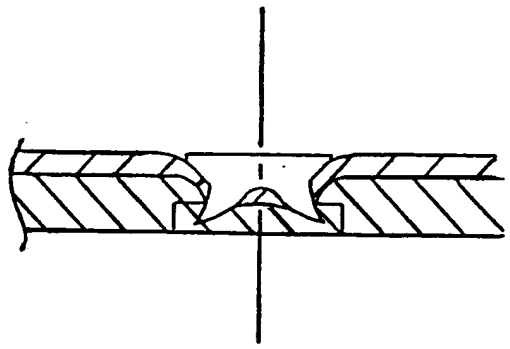

FIG 3A

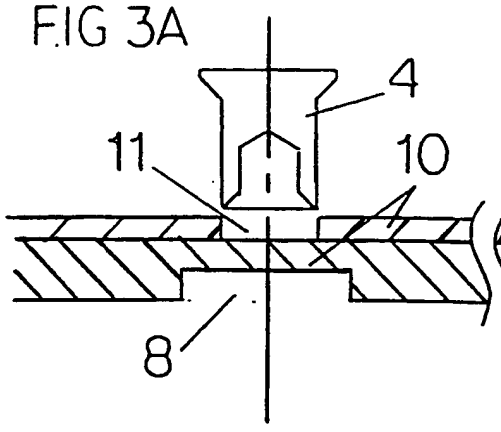

FIG 3B

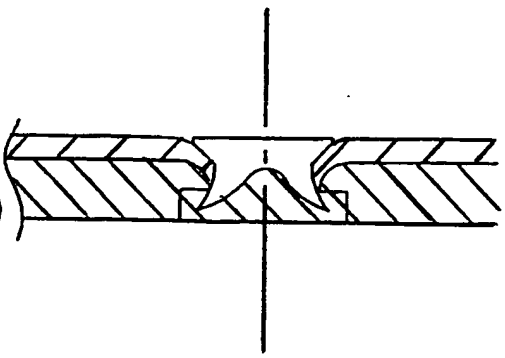

FIG 4A

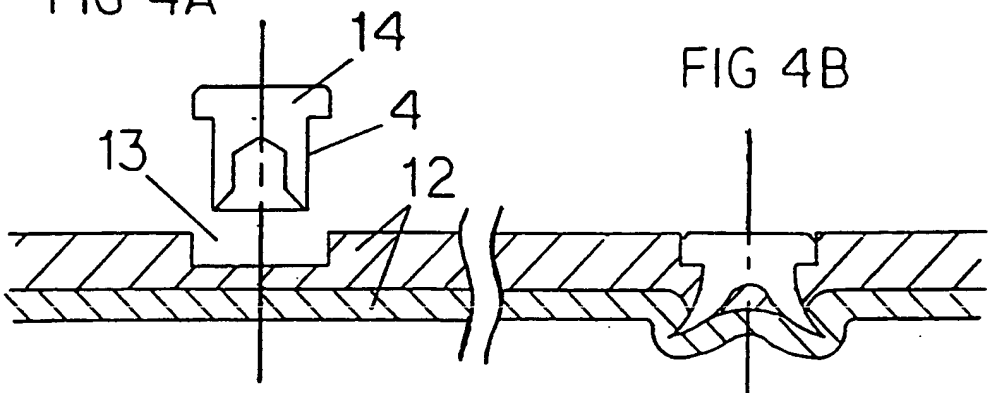

FIG 4B

FIG 5A

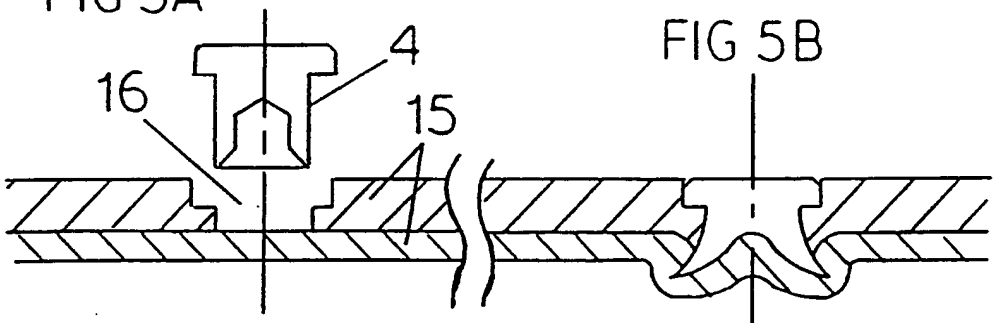

FIG 5B

FIG 6A

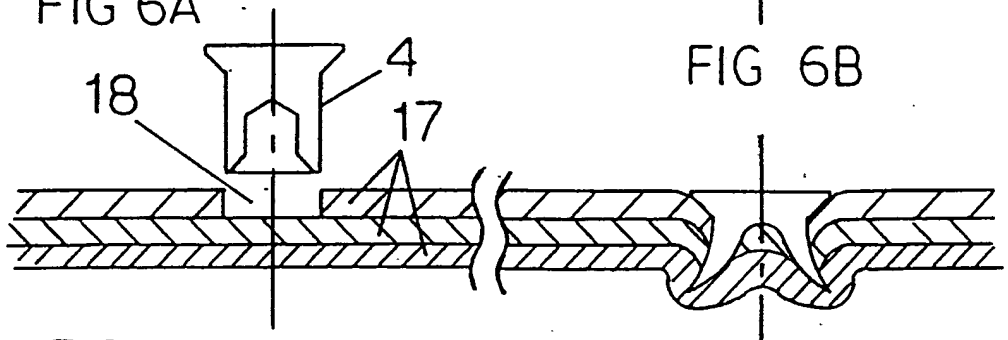

FIG 6B

FIG 7A

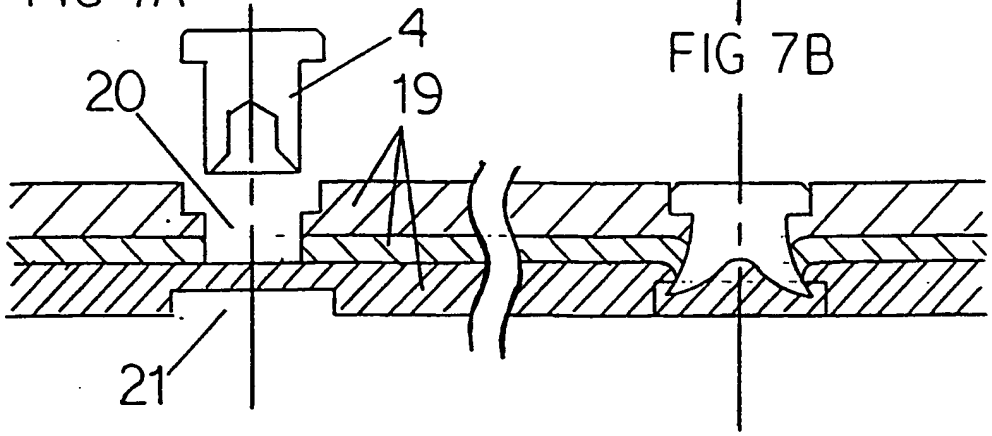

FIG 7B

INTERNATIONAL SEARCH REPORT

Internat ·l Application No
PCT/GB 95/01399

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B21J15/02 F16B19/08 F16B5/04

According to Internatior ·nt Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B21J F16B B23P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR,A,889 237 (NV PHILIPS GLOEILAMPENFABRIEKEN) 4 January 1944 see page 3, line 29 - line 48; figures ---	1,3,5,6, 9
A	US,A,2 753 624 (TAYLOR) 10 July 1956 see the whole document ---	1
A	EP,A,0 129 358 (BL TECHNOLOGY LTD) 27 December 1984 see claim 1; figures -----	1

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☒ Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

mation on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
FR-A-885237	04-01-44	DE-C- 857305 US-A- 2465055	22-03-49
US-A-2753624	10-07-56	NONE	
EP-A-129358	27-12-84	GB-A- 2141369	19-12-84